Appendix O

2007 San Luis Drain Shutoff Study

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Introduction

The Environmental Engineering Research Program (EERP) at the University of the Pacific (UOP) is the lead scientific agency on several water quality and ecosystem restoration projects focused on understanding and improving water quality in the San Joaquin River (SJR). EERP projects include the development of a mass balance on phytoplankton and oxygen demanding materials in the SJR, evaluation of organic carbon sources and fate in the SJR, studies of wetland ecosystems, and studies examining the impact of current agricultural best management practices (BMPs) on water quality. For all of these projects, water quality and water flow must be measured at numerous locations throughout the watershed (Figure 1). One of these locations, San Luis Drain (SLD), was studied during a flow shutoff event to determine the effect of changes in water quality to the SJR.

The San Luis Drain conveys agricultural drainage for about 25 miles from the Grassland Area to Mud Slough (Figure 2). The drainage canal is part of the Grasslands Bypass Project and average summer flows are now about 20 to 25 cubic feet per second (CFS). The primary objective of this experiment was to test the predictive abilities of the San Joaquin River WARMF model to determine what contribution the SLD has to the algae load downstream. Through a coordinated effort by the San Joaquin Valley Drainage Authority, the Grassland Area Farmers, and the Panoche Drainage District, exit flows from the SLD were shutoff by placing boards in each of 16 flow check points and re-circulating upstream farm runoff. The shutoff started on July 23, 2007 and ended on July 26, 2007.

Initial model simulations predicted that a seven day shutoff of the SLD would show a marked decrease in algae loading downstream. If the algae inoculum load from the SLD were removed then an unlimited growth model would predict exponential differences between downstream monitoring points. Such differences were not observed in the data, nor was it obvious that the SLD shut off showed any downstream effect on algae load or concentration.

The EERP collected continuous 15 minute monitoring data from several YSI 6600 sonde multiparameter instruments located at various points above and below the confluence of the SLD with the San Joaquin River. Sondes were deployed from July 10, 2007 to August 21, 2007 for two weeks at a time with instrument exchanges on July 24, 2007 and August 07, 2007. Twice weekly grab samples were taken at 17 sites (Table 1) before, during, and after the shutoff period from July 17, 2007 to August 9, 2007. These samples were taken back to the EERP water lab for further analysis.

Methods

The standard operating procedure (SOP) for deployment of continuously monitoring sonde equipment is described in detail in the EERP Field Protocol Book (Graham and Hanlon, 2008). Calibration, programming and sensor set up were conducted the day prior to deployment at the EERP lab following the SOP. Dissolved oxygen calibration was performed in the field on the day of deployment using the wet-towel method, a technique where the sonde is placed in a tube with a wet-towel around the sensors and calibrated in a water-saturated air environment. The sensor cleaning wiper was fitted with a longer extended deployment brush to better keep the sensors free of algae and debris over the two week period. Sondes were programmed to run unattended for the length of deployment, lasting two weeks, recording each parameter every 15 minutes. The parameters measured by the Sonde at each site include time, temperature (°C), electrical conductivity (mS/cm), total dissolved solids (g/L), dissolved oxygen (DO) percent, DO concentration (mg/L), DO charge, depth of measurement (ft), pH, turbidity (NTU), chlorophyll content (µg/L), chlorophyll-*a* fluorescence, and some instruments were set up to measure oxidation-reduction potential (mV). Upon conclusion of the deployment sondes were retrieved and placed into coolers to keep the membranes moist until post-calibration could be performed. Post-calibration was completed within twenty-four hours of deployment. After being post-calibrated sondes were cleaned with water, the DO membranes and batteries were changed, and the extended deploy wipers were removed (Graham and Hanlon, 2008).

At field sites, instruments were deployed in custom made PVC housings (Figure 3) for protection against vandalism, theft, and other damage. In general, the instruments in their housings were secured with cable to existing structures in the river. The location of our instrument for site DO-05 SJR at Vernalis was the DWR monitoring platform on the SJR near Vernalis, suspended by cable in its own housing (Figure 4). Sites DO-06 SJR at Maze (Figure 5) and DO-07 SJR at Patterson (Figure 6) were on the SJR at the pumping platforms for the El Solyo and Patterson Irrigation districts respectively. Site DO-08 SJR at Crows was on the SJR at the fishing dock of the Turlock Sportsman's club, also the site for other agencies' (DWR) monitoring (Figure 7). The furthest upstream site on the SJR was DO-10 SJR at Lander Ave, located under the Lander Ave. Bridge (Figure 8). This site required wading into the river and driving a fence post into the river bottom to anchor the instrument and housing. Site DO-18 Mud Slough near Gustine was on Mud Slough, the same location as the USGS flow monitoring station and immediately downstream of the confluence with the San Luis Drain (Figure 9). Here the instrument was hung from the middle of the small bridge over the slough. DO-19 Salt Slough at Lander Ave. was on Salt Slough at a USGS station (Figure 10). The instrument was attached to a fence post attached to the bottom of the slough.

Mud Slough receives the effluent from the San Luis Drain and was monitored approximately 1000 ft downstream of their confluence. This water then travels to the San Joaquin River where it enters between DO-08 Crows Landing and DO-10 SJR at Lander Ave. Salt Slough is another major tributary to the San Joaquin River between these monitoring points and so was monitored at DO-19 Salt Slough at Lander Ave. just upstream of its confluence with the SJR. Additional sites were monitored further downstream on the San Joaquin River at DO-07 SJR at Patterson, DO-06 SJR at Maze Blvd., and DO-05 SJR at Vernalis to gauge the effects of the SLD shutoff on the river.

Prior to the shutoff event over a two day period, from July 18 to July 19, 2007, staff from the Panoche Drainage District removed weir boards from several check stations along the drain. Boards were removed from selected checks within the SLD to drop the water level as much as possible, creating storage within the channel for the shutoff event. Weir boards were pulled from downstream to upstream and only in reaches long enough to provide significant storage. The board removal required a crew of four people, as the

10x4 and 8x4 boards were waterlogged and often stuck in place. At the start of the experiment on July 23, 2007, boards were added to all of the checks effectively blocking flow until each reach filled up and began to spill over the boards. The board levels in each check were set to allow approximately 25 CFS of spill before overtopping the channel lining. The boards were gradually returned to their normal settings during the first week of August.

Results and Discussion

A list of sites sampled during the San Luis Drain shutoff study is listed in Table 1. All of the sites were sampled twice a week from July 17, 2007 to August 9, 2007. Samples were collected before the actual drain shutoff to provide background water quality to compare changes along the river. Data was also collected after the flows increased in the drain to catch the water quality changes as they moved downstream. Water quality from other inputs to the San Joaquin River was collected as part of this experiment to provide input for the model.

Discharge from the SLD increased prior to the study on July 21, 2007 when the check boards were removed and storage from each reach was released. The flow reduction of the SLD began the morning of July 23, 2007 when flows dropped from 25 CFS to 10 CFS by noon and down to about 5 CFS by that evening. Flows continued to taper down to about 1 CFS over the next two days. On July 26, 2007 at about noon the SLD had filled to capacity and water began flowing over the last set of weir boards at Check 1, just upstream of the outlet structure. Flow remained steady at about 5 CFS until early July 27, 2007 when the original flow of about 25 CFS was restored. During the first week of August boards were returned to their normal settings by the canal operators. This was done gradually to prevent a large volume of water suddenly being released from the SLD.

Most of the continuous deployment sondes deployed in the field collected reliable data. The sonde at DO-05 SJR at Vernalis did not pass the post-deployment chlorophyll QA on August 7, 2007 due to a faulty chlorophyll probe. DWR had a sonde deployed at this site that was used to replace the low quality data. At DO-10 SJR at Lander Ave. one of the sondes had to be replaced on July 19, 2007 due to a faulty DO membrane and was replaced with a sonde equipped with an optical DO probe. On August 8, 2007 a fish was discovered in the sonde housing at this site. Fish and other organisms living in the housings caused peaks in the turbidity and chlorophyll data. Occasionally the sonde wipers would get fouled and cause wiper parking errors, where the wiper parks over the optical probe resulting in a falsely high reading. These low quality values were removed from the data before analysis.

References

Graham, J., Hanlon, J., 2008. EERP Field Standard Operating Procedures Protocol Book. Environmental Engineering Research Program, Stockton, CA.

Table 1: List of sites sampled during the San Luis Drain Shutoff Study.

Current DO Site Number	Sample Station Name	Latitude	Longitude
4	SJR at Mossdale	37.78710	-121.30757
5	SJR at Vernalis-McCune Station (River Club)	37.67936	-121.26504
6	SJR at Maze	37.64142	-121.22902
7	SJR at Patterson	37.49373	-121.08081
8	SJR at Crows Landing	37.43197	-121.01165
10	SJR at Lander Avenue	37.29424	-120.85125
12	Stanislaus River at Caswell Park	37.70160	-121.17719
14	Tuolumne River at Shiloh Bridge	37.60350	-121.13125
16	Merced River at River Road	37.35043	-120.96196
18	Mud Slough near Gustine	37.26250	-120.90555
19	Salt Slough at Lander Avenue	37.24795	-120.85194
21	Orestimba Creek at River Road	37.41396	-121.01488
28	Turlock ID Westport Drain Flow station	37.54196	-121.09408
29	Turlock ID Harding Drain	37.46427	-121.03093
30	Turlock ID Lateral 6 & 7 at Levee	37.39782	-120.97225
34	Ingram Creek	37.60026	-121.22506
36	Del Puerto Creek Flow Station	37.53947	-121.12206

Figure 1: Map of the study area and sampling locations.

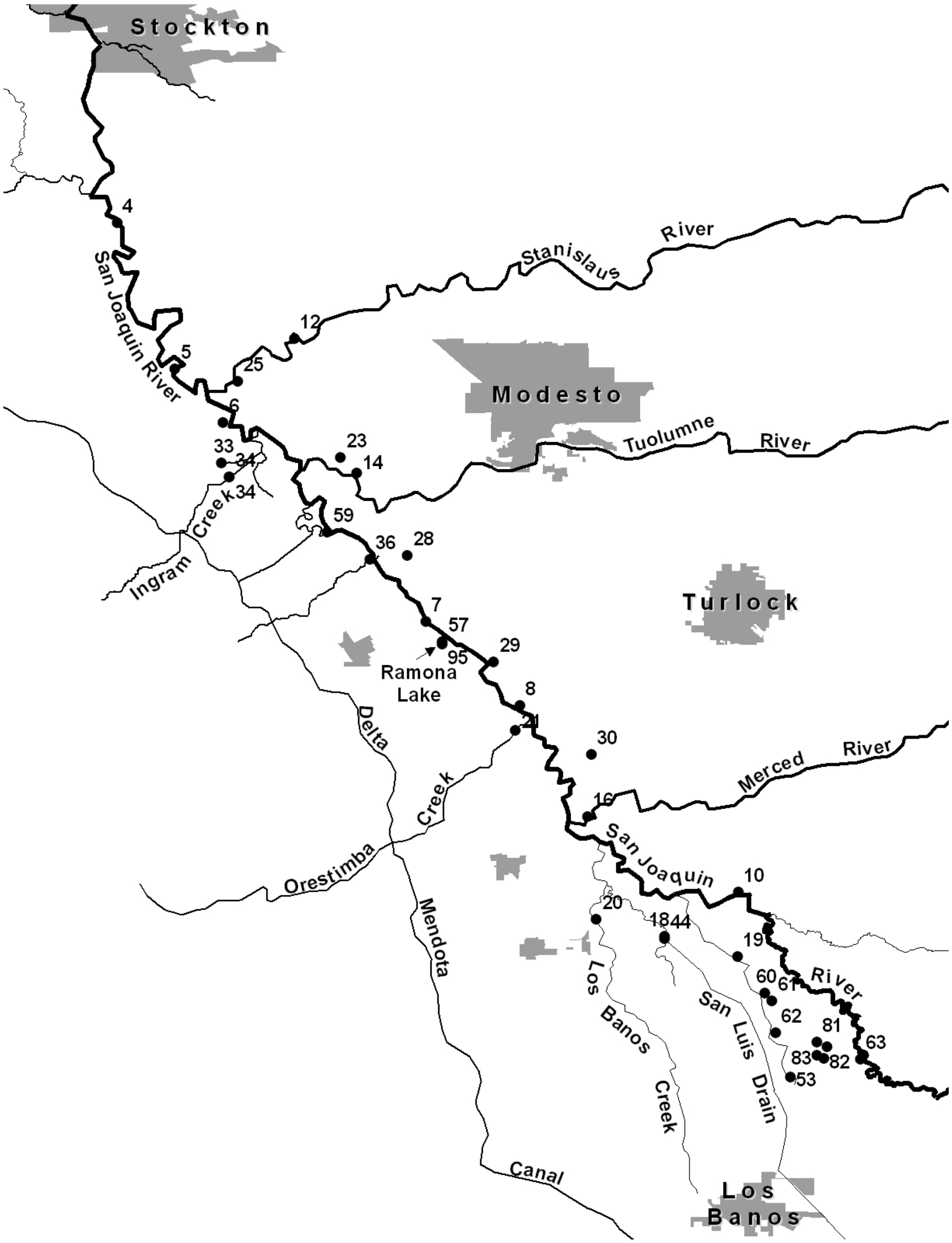

Figure 2: Map of the San Luis Drain located in the San Joaquin Valley of California. The San Luis Drain is a concrete lined channel that conveys agricultural drainage from farms in the south, past sensitive wetland areas, and discharges into the San Joaquin River via Mud Slough.

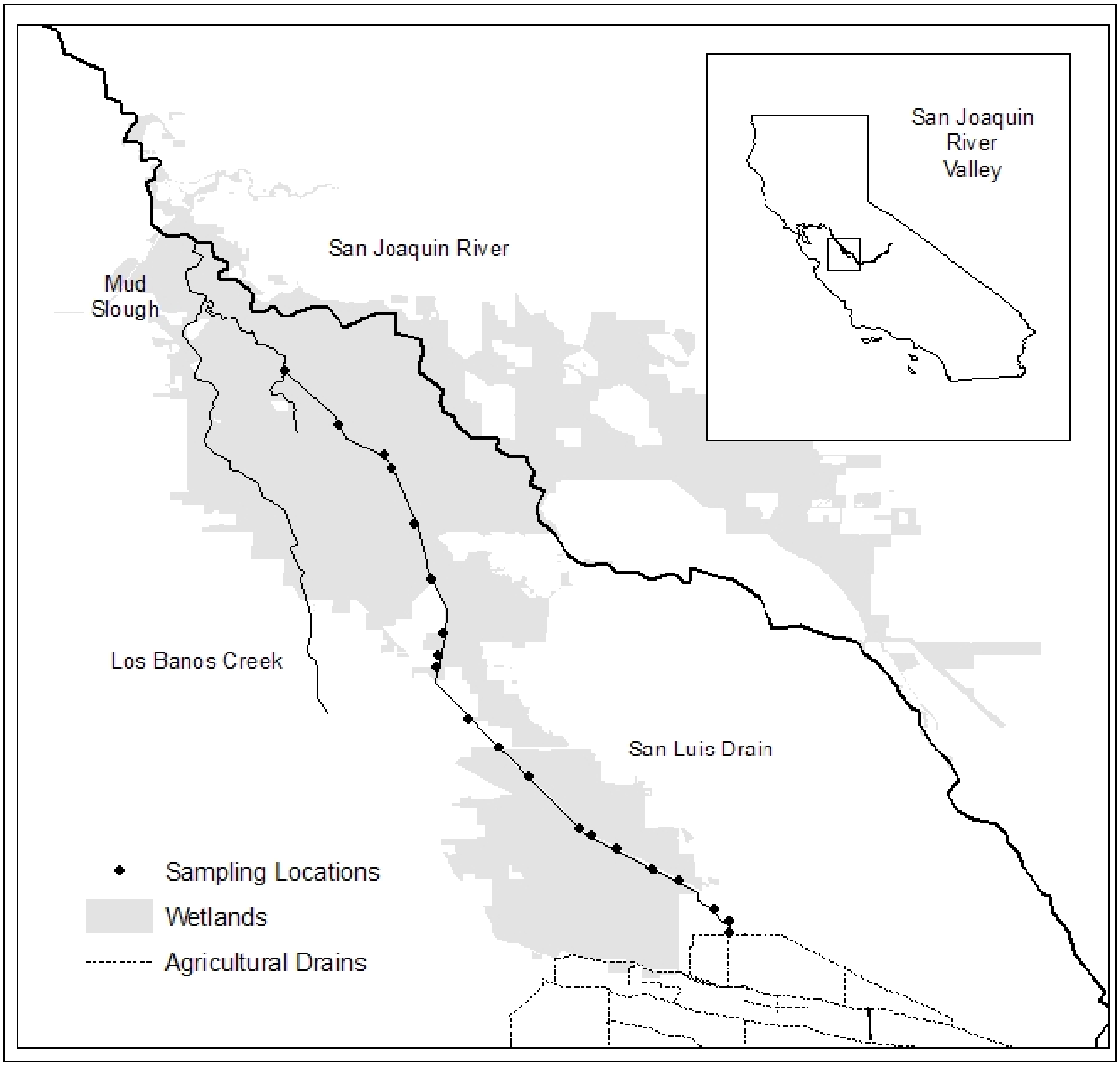

Figure 3: YSI Sonde 6600 with deployment housing.

Figure 4: View from DWR Vernalis platform DO-05 looking down at river and stilling wells.

Figure 5: El Solyo Water District intake structure on San Joaquin river, DO-06.

Figure 6: Patterson Irrigation District intake structure on San Joaquin river, DO-07.

Figure 7: Turlock Sportsmans club fishing dock, DO-08.

Figure 8: San Joaquin River at Lander Ave., DO-10.

Figure 9: Mud Slough near Gustine, DO-18.

Figure 10: Salt Slough at Lander Ave., DO-19.

Figure 11: San Luis Drain terminus, DO-44.

Figure 12: Bridge across SLD about 200 ft upstream of End of Drain outfall (DO-44) Profile was done in middle of bridge.

Figure 13: Plot of chlorophyll fluorescence by depth for SLD end.

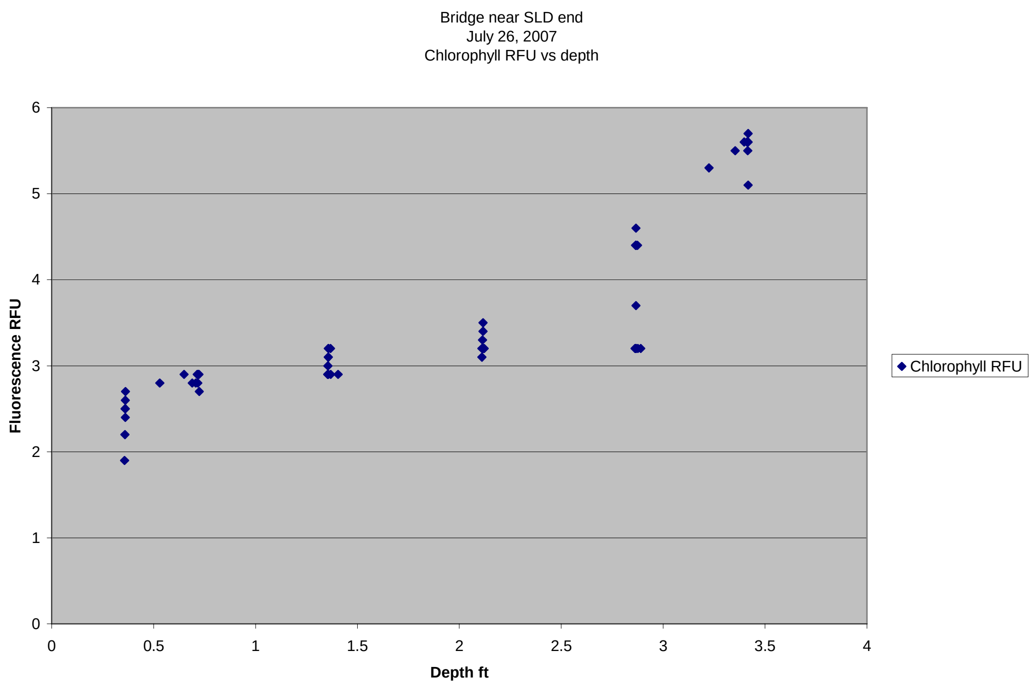

Figure 14: Check Station 1 had leaky boards, sonde profile was performed from wall near boards.

Figure 15: Check Station 1 had leaky boards, sonde profile was performed from wall near boards.

Figure 16: Chlorophyll fluorescence as a function of depth for SLD Check 1.

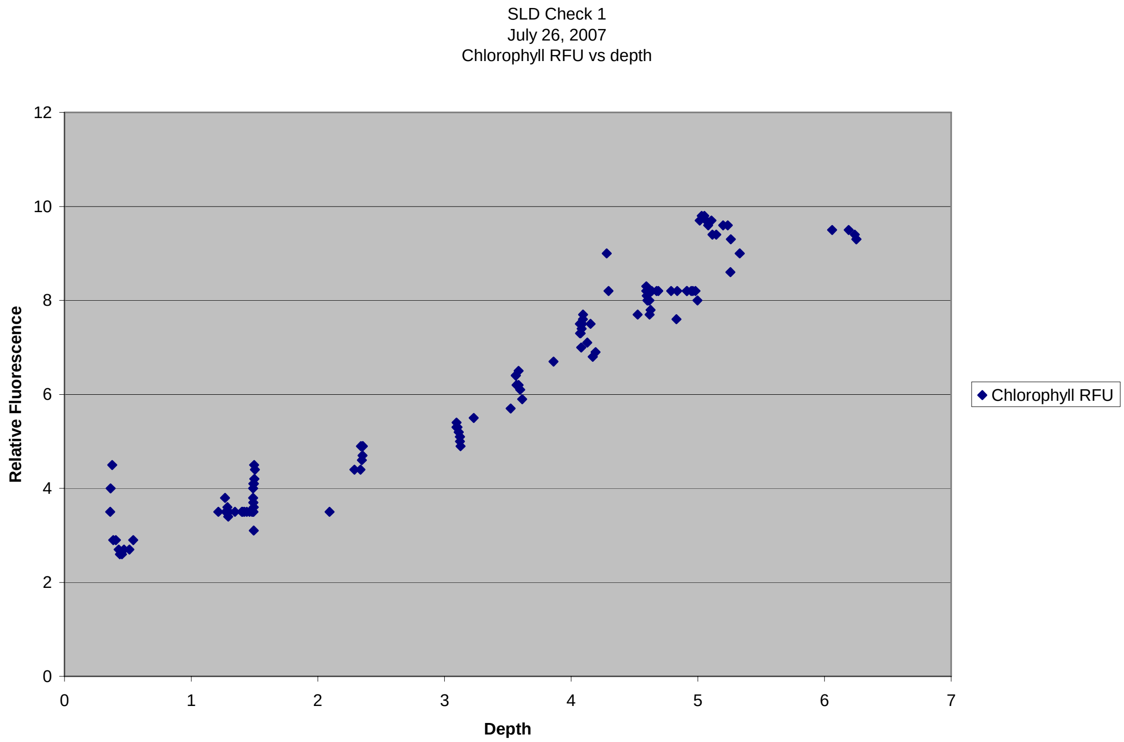

Figure 17: Check Station 2 water had begun to flow over the boards, sonde profile was done from platform where stilling well is located.

Figure 18: Check Station 2 water had begun to flow over the boards, sonde profile was done from platform where stilling well is located.

Figure 19: Plot of chlorophyll fluorescence as a function of depth for SLD Check 2.

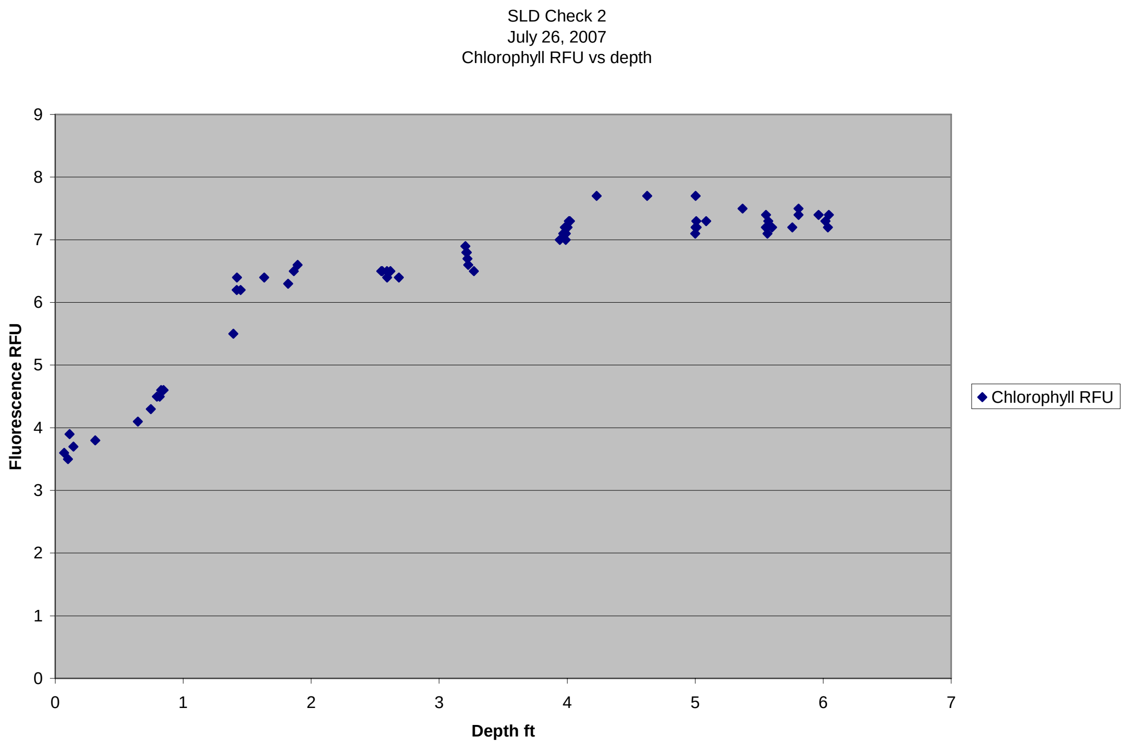

Figure 20: Check Station 3 water was flowing over boards, sonde profile was done from concrete bridge immediately in front of boards.

Figure 21: Check Station 3 water was flowing over boards, sonde profile was done from concrete bridge immediately in front of boards.

Figure 22: Check Station 3 plot of chlorophyll fluorescence as a function of depth.

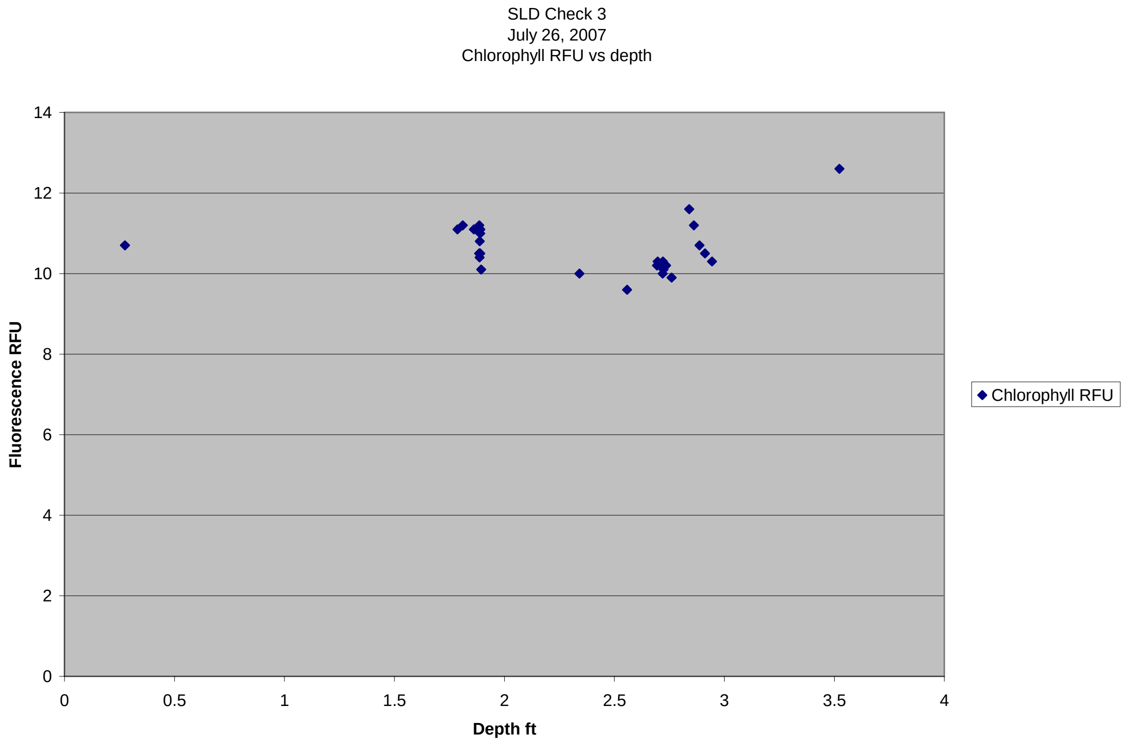

Figure 23: Check Station 4 water flowing over boards, sonde profile was performed from concrete bridge directly in front of weirboards.

Figure 24: Check Station 4 water flowing over boards, strong current made it difficult to keep instrument in place.

Figure 25: Check Station 4 chlorophyll fluorescence as a function of depth.

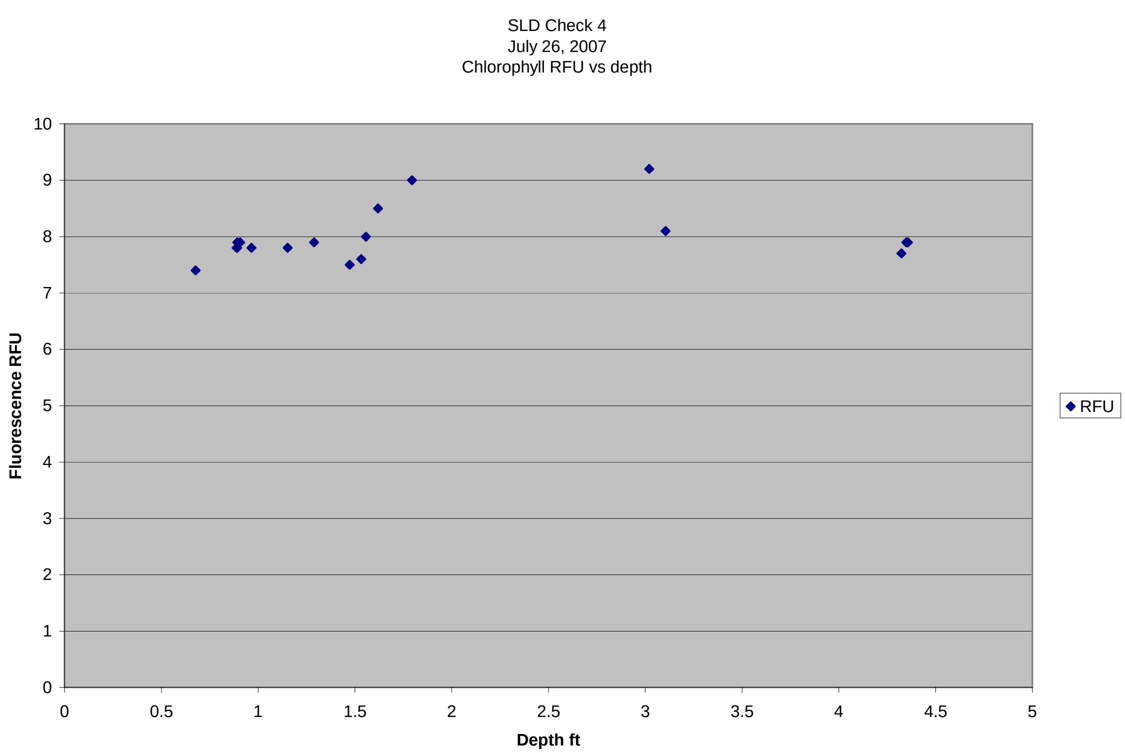

Figure 26: Algae loads from upstream tributaries (DO-10, DO-19) and downstream of San Luis Drain before, during and after the shutoff experiment.

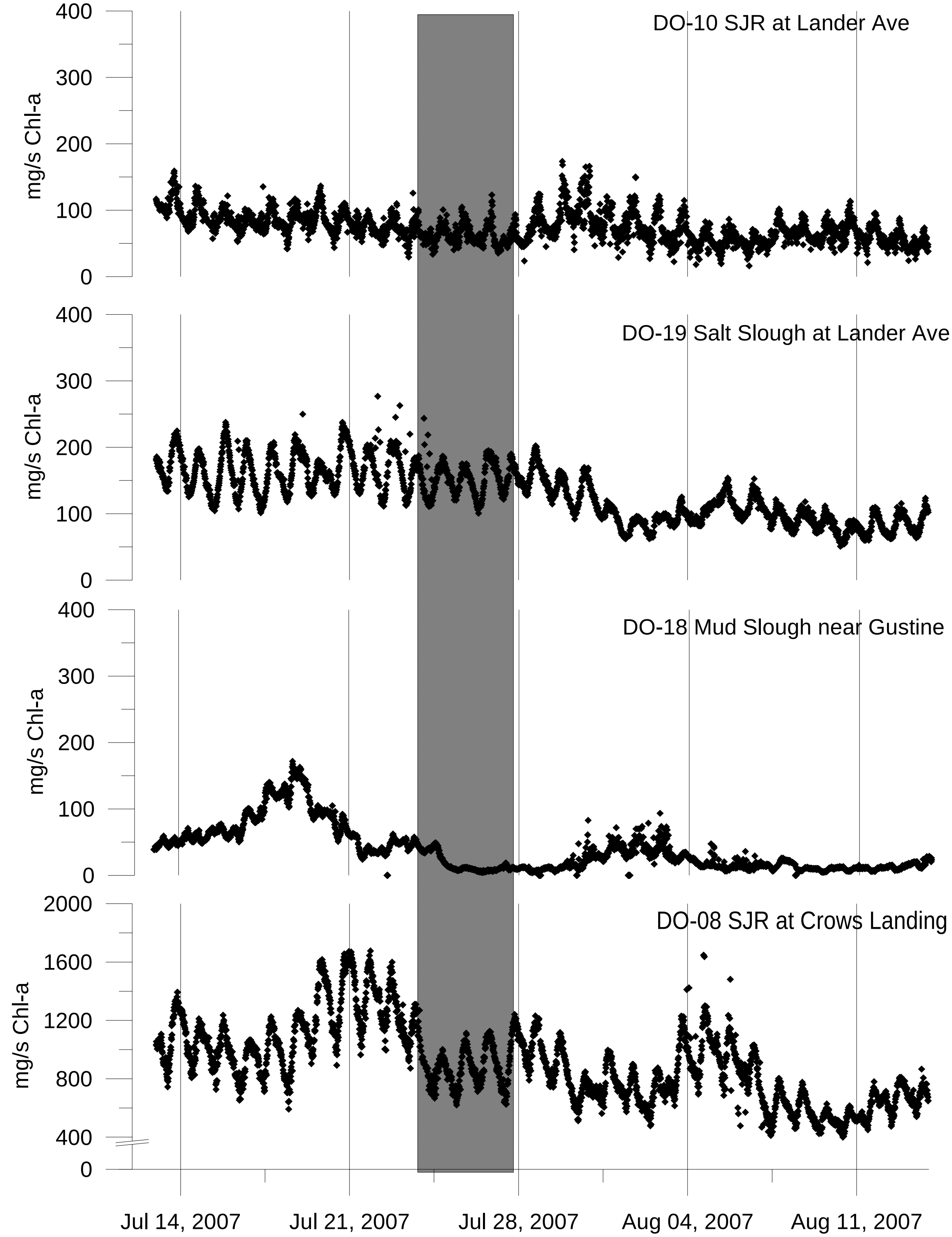

Figure 27: Chlorophyll fluorescence values from other tributaries and downstream of San Luis Drain before, during, and after the shutoff experiment.

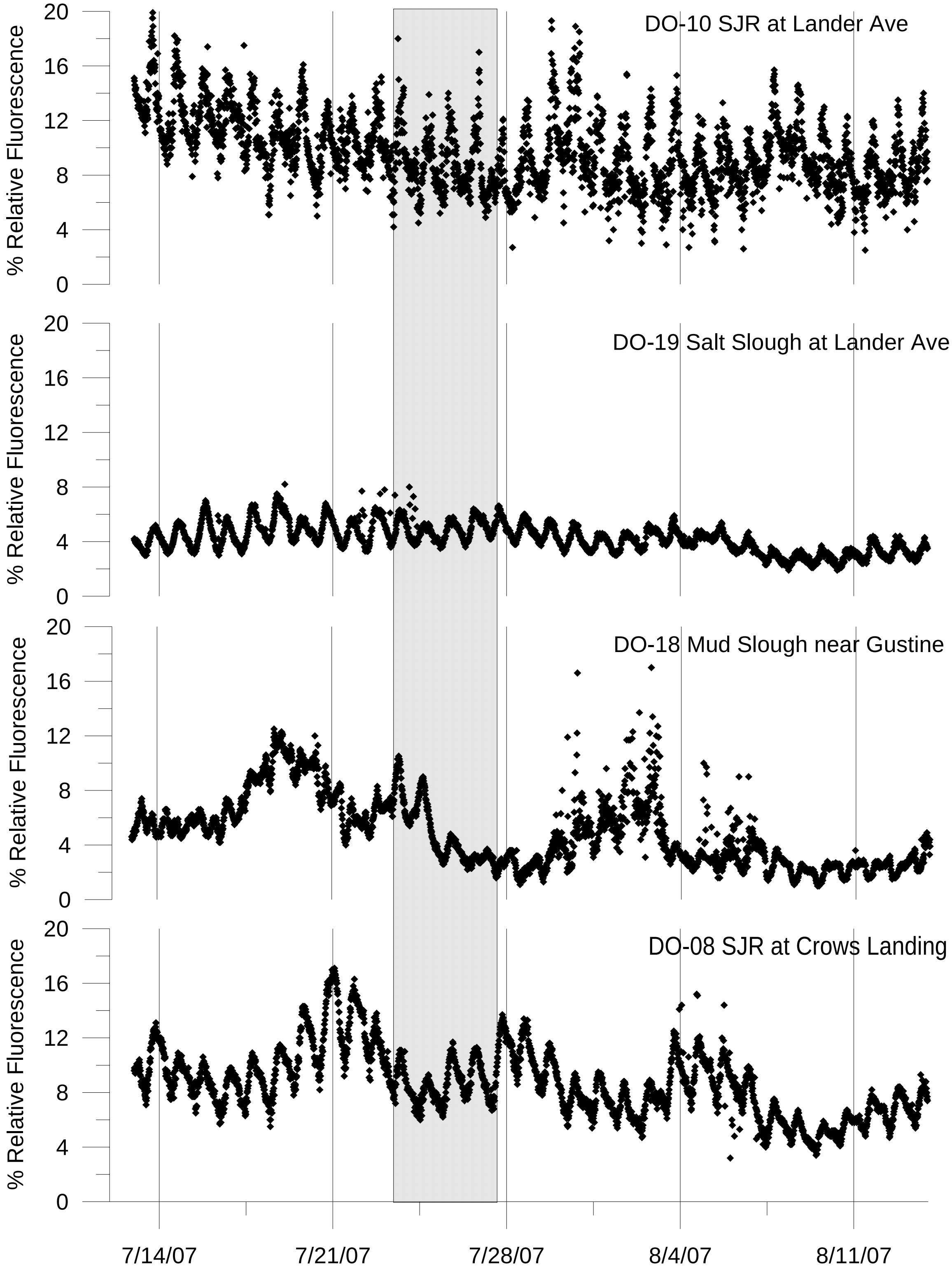

Figure 28: Salt load from other tributaries and downstream of San Luis Drain before, during, and after the shutoff experiment.

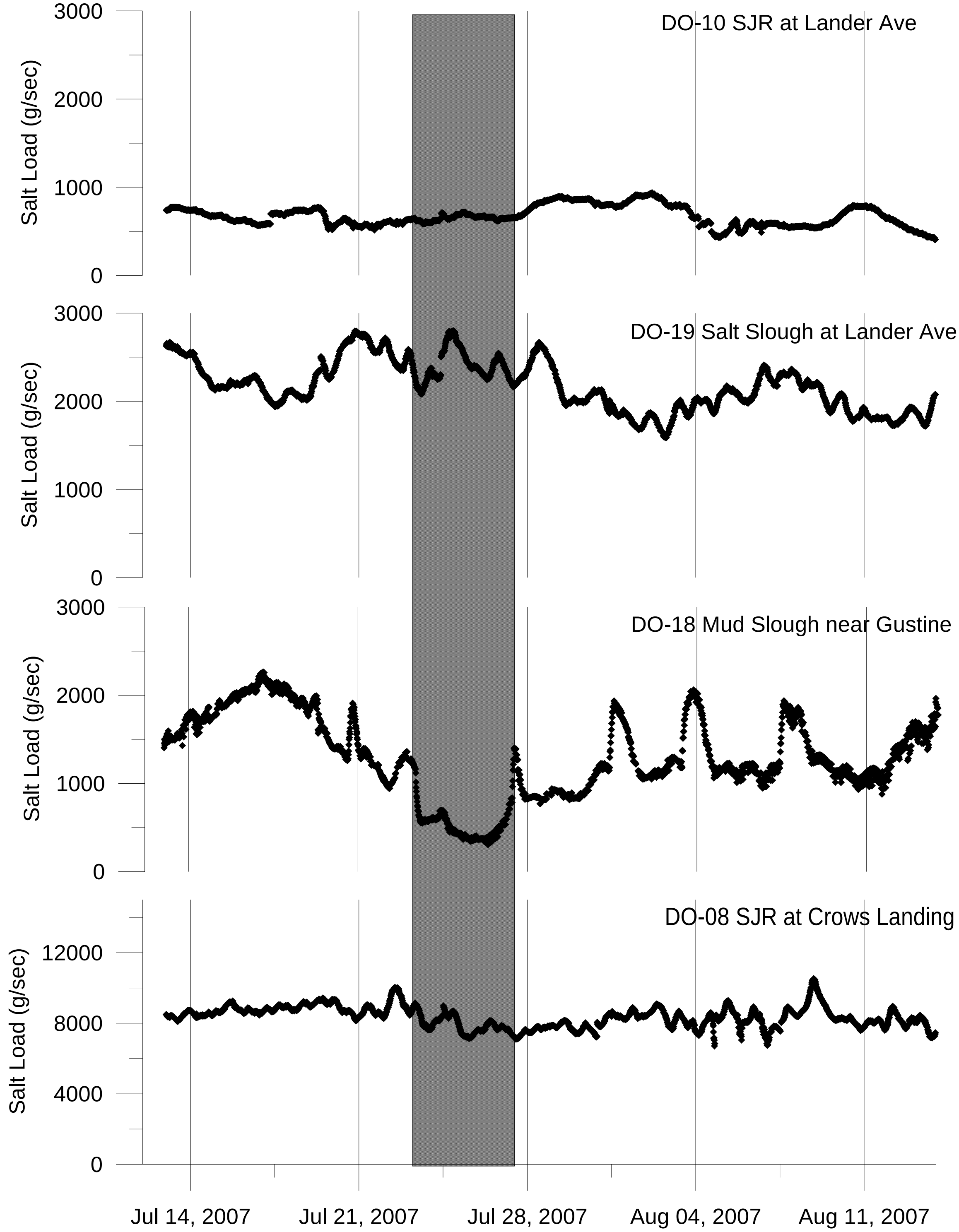

Figure 29: Specific conductance from other tributaries and downstream of San Luis Drain before, during, and after the shutoff experiment.